

APPLICATION
FOR
UNITED STATES LETTERS PATENT

Specification

To all whom it may concern:

Be it known, that we, Hiroshi Akino, Tatsuo Koike and Shioto Okita, all
c/o Kabushiki Kaisha Audio-Technica, 2206, Naruse, Machida-shi, Tokyo, Japan,
citizens of Japan have invented PHANTOM POWERED CAPACITOR
MICROPHONE AND A METHOD OF USING A VACUUM TUBE IN THE SAME
of which the following is a specification:

TITLE OF THE INVENTION

PHANTOM POWERED CAPACITOR MICROPHONE AND A METHOD OF
USING A VACUUM TUBE IN THE SAME

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FIELD OF THE INVENTION

The present invention relates to a capacitor microphone powered by a
phantom power supply (a phantom powered capacitor microphone) and especially
10 relates to the phantom powered capacitor microphone and a method of using a
vacuum tube as an impedance converter of a microphone capsule thereof.

BACKGROUND OF THE INVENTION

15 A FET (Field Effect Transistor) or a vacuum tube is used as an impedance
converter of a capacitor microphone, because impedance between a vibrating plate
and a fixed electrode placed and faced to each other in a capacitor microphone
capsule is remarkably high.

When a vacuum tube is used as an impedance converter of a capacitor
20 microphone, exclusive power supplies generally need to be prepared. A heater
power supply for heating a heater and a plate power supply for flowing a plate
current are necessary for operating the vacuum tube.

Generally, a vacuum tube which is used as an impedance converter needs a
heater power supply of 6.3V, 0.35A and a plate power supply of 120V, 10mA.
25 Therefore, since a general 48V phantom power supply cannot afford to supply that
power, the exclusive power supplies are used.

A dry battery powered vacuum tube which has small power consumption is in existence. For example, type no.6418 of a directly heated pentode vacuum tube of Raytheon company meets the requirement. This vacuum tube has been developed for a hearing aid and can be operated by a heater power supply of 1.25V,
5 10mA and a plate power supply of 30V, 0.24mA.

A vacuum tube which has as small the power consumption as the above-described power can be operated by the general 48V phantom power supply. However, when the heater power of 1.25V, 10mA is directly stabilized from the phantom power by a zener diode or the like, the voltage supplied from the
10 phantom power supply is decreased because the current of 10mA flows to the heater of the vacuum tube.

For example, when 10mA flows to the heater of the vacuum tube, the voltage supplied to the microphone from the phantom power supply decreases the voltage of 34V ($5\text{mA} \times 6.8\text{k}\Omega$) and the voltage supplied to the microphone results
15 in 14V. In this condition, the power supplied to the plate of the vacuum tube is insufficient and the vacuum tube cannot be operated.

Therefore, it is contemplated that a down-converter which converts a higher voltage to a lower voltage can be used. That is, a larger current is obtained from a smaller current by the down-converter. However, following problems will
20 occur.

One of the problems will described hereinafter. Many converting methods for down converters are available. However, the pulse width modulation method, such as used in type no.MAX1733 of Low-Voltage Step-Down DC-DC Converter of Maxim Integrated Products, is generally used.

25 Since in the converter using the pulse width modulation method, the input voltage of the converter is switched on and off, large noise is generated because of

the switching. The noise enters to a supply voltage, and then, the noise increases a microphone noise.

Further, since an inductor is used in the pulse width modulation converter, an external magnetic field is generated by the current with noise flowing in the inductor and the external magnetic field is magnetically coupled with an output transformer of a microphone, whereby the microphone noise is generated.

The other problem is that the down-converter which can convert 10V to 1.25V is rarely-offered in markets, because it's application is limited.

SUMMARY OF THE INVENTION

The subject matter of this invention is that in a phantom powered capacitor microphone of which a vacuum tube is used as an impedance converter, in order to heat the heater of the vacuum tube a heater power supply including a down-converter which generates no noise and which is easily-offered in markets is obtained from the phantom power supply.

To achieve the above-described subject matter, it is characterized in that in the phantom powered capacitor microphone of which the vacuum tube is used as the impedance converter, a part of the voltage supplied from the phantom power supply is converted to the predetermined voltage by one or more switched capacitor voltage converters to obtain the heater voltage of the vacuum tube.

The switched capacitor voltage converter includes an oscillator for a switching control, a semiconductor switch having a CMOS or the like and an external capacitor storing electric charge. The oscillator switches on and off the semiconductor switch to charge and discharge the capacitor, so that the output voltage of the converter is double-boosted or half-stepped down from the input

voltage. For example, one of these kinds of converters is type no. LM2665 of National Semiconductor Corporation.

Since the electric charge of this kind of the converter is controlled only by charge and discharge of the capacitor, the noise generated in the switched capacitor voltage converter is not as large as in the pulse width modulation converter. The output voltage of the switched capacitor voltage converter is proportional to the input voltage thereof, and then, the stabilized output voltage of the converter is obtained based on the stabilized input voltage thereof.

Therefore, an input circuit is connected to the input of the switched capacitor voltage converter to stabilize the input voltage of the converter. The input circuit includes a zener diode to stabilize the input voltage of the converter and a smoothing capacitor to more stabilize the voltage. The circuit further includes a current limit resistor. The resistor is disposed at the up-stream of the zener diode to set the current flowing to the converter to a predetermined value ,whereby an optimized voltage and an optimized current are supplied to the heater of the vacuum tube from the heater power supply.

The voltage supplied from the phantom power supply applies to a constant current circuit and the stabilized output current from the constant current circuit is divided to flow to the plate of the vacuum tube and to the current limit resistor of the input circuit. Therefore, the predetermined value of the plate current is supplied to the plate of the vacuum tube and the predetermined value of the heater current is also supplied to the heater of the vacuum tube.

According to this invention, a dry battery powered vacuum tube having small power consumption is preferably employed as the vacuum tube which is used as the impedance converter of the capacitor microphone capsule. For example, one of these kinds of the vacuum tubes is type No.6418 of a directly

heated pentode vacuum tube of Raytheon company.

BRIEF DESCRIPTION OF THE DRAWINGS

5 FIG. 1 is a capacitor microphone circuit diagram showing one aspect of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

10 An embodiment of this invention will be described according to a circuit diagram of a capacitor microphone 1 as shown in FIG. 1. The capacitor microphone of this invention is powered by a phantom power supply (phantom powered capacitor microphone). The phantom power supply (not shown), which is publicly known, includes two $6.8k\Omega$ resistors seriously connected between the hot
15 side and the cold side of the balance-transmission and a DC 48 V power supply connected between the connecting point of the two resistors and the ground.

 In FIG. 1 MC is a microphone capsule (so called a mike) of the capacitor microphone. The capsule is an electret capacitor type microphone capsule in this embodiment, however the capsule also may be a kind of a capsule which needs a
20 polarization power supply.

 V01 is a vacuum tube which is used as an impedance converter connected to the microphone capsule MC. In this embodiment, type no.6418 of a directly heated pentode vacuum tube of Raytheon company is used. The vacuum tube V01 can be operated by a heater power supply 1.25V, 10mA and a plate power supply
25 30V, 0.24mA.

 R01 is a bias resistor for the control grid of the vacuum tube V01. C01 is a

feed back capacitor from the plate to the control grid of the vacuum tube V01. R02 and R03 are voltage dividing resistors to apply voltage to the screen grid of the vacuum tube V01.

5 A microphone output is provided with terminals H, C and G, respectively, connected to the hot side, the cold side and the ground side of the phantom power supply. The terminals H and C are connected to the vacuum tube V01 through an output transformer TRS. Connected to the terminal G are the ground of the microphone capsule, the ground of the heater of the vacuum tube V01 and so on.

10 The capacitor microphone includes a heater power generator 10 for supplying a heater power to the vacuum tube V01 from the phantom power supply. The generator 10 includes at least one switched capacitor voltage converter IC (Integrated Circuit). Hereinafter the switched capacitor voltage converter IC may be abbreviated as the converter IC. The output of the generator is connected to the heater of the vacuum tube V01.

15 In this embodiment, IC01, IC02 and IC03 of three converter ICs are seriously connected as three stages, each of which is type no. LM2665 of National Semiconductor Corporation.

20 The LM2665 converter IC has a 6-pin configuration. When a positive voltage is inserted to No.1 pin of the IC, the voltage output from No.5 pin is two times higher than the input voltage. That is, the converter IC is operated as a double boosting voltage converter. To the contrary, when a positive voltage is inserted to No.5 pin of the IC, a half of the input voltage is output from No.1 pin, in which the converter IC is operated as a half step down converter.

25 In this embodiment, each of the converter ICs is operated as a half step down converter, and each of the positive voltages is inserted to each of No.5 pins of IC 01, IC02 and IC03 to obtain a half of the input voltage from each of No.1 pins.

No.2 pin of the converter IC is a ground pin and No.4 pin is a shutdown control pin. Charge pump capacitors C06, C08 and C10 are connected, respectively, between No.3 and No.6 pins of each of the converter ICs. In this embodiment, since each of the converter ICs is operated as the half step down
5 converter, each of the positive leads of the charge pump capacitors is connected to each of No.3 pins of the converter ICs. When each of the converter ICs is operated as the double boosting voltage converter, each of the negative leads of the charge pump capacitors is connected to each of No.3 pins of the converter ICs. Connected, respectively, to each of No.1 pins which are the outputs of the converter ICs are
10 capacitors C05, C07 and C09 for smoothing current and passing AC (Alternative Current) to the ground.

Connected to the heater power generator 10 is an input circuit 10a having a current limit resistor R04, a zener diode D01 and a capacitor C11. The resistor and the diode seriously connected. Connected to the input circuit 10a is a constant
15 current circuit 10b having a first and a second constant current diodes D02, D03 to flow a predetermined value of current to the input circuit 10a from the terminals H and C connected to the phantom power supply.

In this embodiment, the power of 30V, 1.5mA is supplied to the input circuit 10a from the first and the second constant current diodes D02, D03 of the
20 constant current circuit 10b. The zener diode D01 of the input circuit 10a restricts 30V to 10V as the input voltage of the heater power generator 10 and the current limit resistor R04 restricts the input current of the heater power circuit to 1.25mA.

In the first, the second and the third converter ICs IC03, IC02 and IC01, the voltage of 10V is converted to 5V, to 2.5V, and to 1.25V in sequence. The
25 current of 1.25mA is also converted to 2.5mA, to 5.0mA, and to 10mA in sequence. The heater power of 1.25V, 10mA results to be supplied to the heater of the

vacuum tube V01 from the third converter IC.

Thus, since the current flowing into the heater power generator 10 from the phantom power supply is only 1.25mA, the voltage drop due to heating the heater is only approximately 4.25V ($0.5 \times 1.25\text{mA} \times 6.8\text{k}\Omega$) so that the plate power for
5 flowing the plate current of the vacuum tube V01 is sufficiently ensured. In FIG. 1, the reference symbols and numerals C02, C03, C04 and C11 are smoothing capacitors.

According to the above-described present invention, in the phantom powered capacitor microphone of which the vacuum tube is used as the impedance
10 converter, a part of the voltage supplied from the phantom power supply is converted to the predetermined voltage by one or more switched capacitor voltage converters to obtain the heater voltage of the vacuum tube, whereby the low noise phantom powered vacuum tube capacitor microphone with no exclusive power supply is provided.